

Middle School Students' Heart Rates during Different Curricular Activities in Physical Education

by Zan Gao, James C. Hannon, and Russell L. Carson

Abstract

The purpose of this study was to determine if students' heart rate outcomes in physical education varied as a function of activity and grade. A total of 146 sixth to eighth graders participated in different activities (i.e., walking/jogging, line dancing, soccer, and catch ball). Their average heart rate (AHR) and percentage of time in and above target heart rate (PTHR) were used as outcome variables. The results yielded that students in line dancing exhibited significantly lower PTHR than other classes; no significant differences were found with AHR across the activities. Younger students (i.e., sixth graders) displayed significantly higher AHR and PTHR than older students (i.e., eighth graders). Educators must consider physiological effects that different activities may have on students when designing and implementing physical education programs.

Key words: physical activity, grade levels, heart rate

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Despite the positive physical and psychological benefits of physical activity (PA), a large proportion of children and adolescents do not participate in organized or free time PA during their non-school hours (Centers for Disease Control [CDC], 2003; U.S. Department of Health and Human Services [USDHHS], 1996). Given the fact that individuals' health-related behaviors during childhood and adolescence have a positive influence on their exercise behaviors during adulthood, it is crucial for young people to develop and maintain a physically active lifestyle. Because nearly all children participate in physical education (Ross & Gilbert, 1985), school physical education programs have the potential to increase PA levels for all children and therefore can play a critical role in promoting public health (Wallhead & Buckworth, 2004). National Health Objective 22-10 calls for all students to be physically active for at least 50% of physical education class time (USDHHS, 2000). In fact, Sallis and Patrick (1994) have suggested that 50% of the physical education class time should involve moderate to vigorous physical activity (MVPA) to elicit cardiovascular fitness gains. However, research studies have consistently indicated that physical education programs are not meeting the Healthy People 2010 goal of a minimum of 50% of the class time spent in PA (USDHHS, 2000). To address this issue, physical education curricular activities should emphasize and encourage the increase of class time spent being physically active.

It is posited that curricular activities may influence students' PA levels in physical education (Fairclough & Stratton, 2005, 2006; Laurson, Brown, Cullen, & Dennis, 2008; McKenzie, Marshall, Sallis, & Conway, 2000). In general, invasion team sports (i.e., soccer and basketball) usually promote relatively higher mean heart rates (Klausen, Rasmussen, & Schibye, 1986) and MVPA

(Stratton, 1997) than individual activities. Nevertheless, empirical studies have revealed various findings as researchers have investigated a large variety of curricular activities. For example, Macfarlane and Kwong (2003) found that students were more active (highest heart rates) during team sport activities (e.g., soccer, basketball, and football) and during free play than during gymnastics. In their studies using heart rate monitors, Kulinna and colleagues (2003) reported that the highest heart rates were identified during hula-hoop, volleyball, fitness, and soccer. Hannon and Pellett (1998) also reported that students in team sport activities and fitness activities spent at least 20 minutes out of the 30-minute physical education classes in a moderate heart rate zone. Most recently, Laurson and colleagues (2008) indicated that, for high school students, fitness activities promoted significantly higher average heart rate and percentage of activity time spent within a target heart rate zone than team sports and individual sports. Due to the inconclusive findings, more research endeavors investigating the impact of curricular activities in physical education on heart rate outcomes are warranted, especially within the middle school years. In the present study, various types of curricular activities were classified as team sports, individual activity, and fitness activity. Specifically, in team sports classes, students were divided into teams to play traditional sports or games (i.e., soccer, and catch ball). In individual activity classes, students played traditional games and activities that did not divide them into teams (i.e., line dancing). In fitness activity classes, students focused on activities promoting health enhancement and lifetime fitness (i.e., walking/jogging). The fitness activity also did not require students to be divided into teams or groups for competition.

It has been evident that students differ in their PA levels in physical education classes across different grades and age groups (e.g., Kulinna et al., 2003; Stratton, 1997; Vincent & Pangrazi, 2002). That is, students' PA levels decline dramatically with increasing age and grade levels during adolescence, especially during the middle school years (USDHHS, 1996). Specifically, Parish and Treasure (2003) reported that students' pedometer-determined PA levels declined from sixth to eighth grade. Stratton (1997) found that students' heart rates increased from nine to ten years of age, peaked at 11 to 12 years of age, and then decreased in later school years. Klausen and colleagues (1986) also found that heart rates in physical education were lower in older children (aged 12 to 13 years) than in younger children (aged 10 to 11 years). Kulinna et al. (2003) further indicated that elementary school children displayed the highest heart rates, followed by high school and middle school students. No known studies are available in terms of the grade differences in heart rate outcomes within middle school students and our investigation aimed to provide new empirical evidence for all three middle school grade levels in this area of inquiry.

In sum, the main purpose of this study was to determine if students' heart rate outcomes differed as a function of activity and

grade level. Based on previous studies and the literature reviewed, it was hypothesized that students would exhibit higher levels of heart rate outcomes (average heart rate [AHR] and percentage of time in and above target heart rate [PTHR]) in the team sports and fitness activity than those in the individual activity. Second, it was hypothesized that younger students (sixth graders) would exhibit higher AHR and PTHR than older students (eighth graders).

Method

The Participants and Research Setting

The participants were 146 middle school students (77 boys, 69 girls) enrolled in one public school in the Southern region of the United States. The participants consisted of sixth ($n = 51$), seventh ($n = 33$), and eighth ($n = 62$) graders ranging in age from 10 to 14 years (M age = 12.50, $SD = 1.06$). The majority of the participants, 87.7%, were Caucasian, with 8.9% African-American, 2.7% Hispanic American, and .7% Asian American.

The participants had a 90-minute physical education class taught by three physical education teachers on alternate days. All the teachers had earned master's degrees in physical education teacher education and had at least 10 years of teaching experience. They shared the responsibility for the teaching assignments in the three classes of each grade. More specifically, the teachers taught each class of each grade by rotation and thus the teacher effect on the heart rate outcomes was minimized. Given the time allotted for changing clothes and roll check, the participants had approximately 60 minutes to do activities in class. Prior to the start of data collection, permission to conduct the study was obtained from the University Institutional Review Board, the school district, the principal, and the physical education teachers. Child assent and parent or guardian permission to participate in the study was also obtained prior to data collection.

When students arrived at the gym, the physical education teachers took attendance. Then the students participated in a warm-up, followed by the activities for the day. Physical education classes were held indoors for catch ball and line dancing and outdoors for walking/jogging and soccer. The breakdown of the participants in each curricular activity were as follows: 30 participants in walking/jogging, 22 participants in line dancing, 60 participants in catch ball, and 34 participants in soccer.

In the walking/jogging class, students spent the majority of time walking or jogging around the school campus with very limited instruction (e.g., the teachers focused primarily on the management of the class). The line dancing class included introducing skills to be learned, organizing students for practice during the middle of the class, and providing closure to the lesson at the end of the class. For the catch ball class, the students played games under teachers' supervision following the warm-up activities during the data collection period. Specifically, instructions and rules (i.e., the same rules as ultimate Frisbee) were given before the start of this study by the teachers. Students were assigned into two squads and then competed against each other. At the start of class, the teachers reinforced the game rules and then allowed the game to commence. The soccer class was organized in the same way as the catch ball class. It is important to note that no formalized instruction was given throughout the soccer class and the catch ball class.

Instruments

Demographic information was gathered using a short survey regarding the students' age, grade, gender, and ethnicity. Students' heart rate based PA in physical education classes were measured via Polar E 600 heart rate monitors (Polar Elector OY, Finland). The heart rate monitor was set to record data at 5-second intervals. To download data, the receiver of the heart rate monitor was interfaced with the computer and data outputs were transferred to the Polar software. Heart rate data can be expressed in a variety of ways (Durant et al., 1993). To provide comparisons of different heart rate measures, two different output measures were analyzed in the physical education classes (Kulinna et al., 2003). The first measure was each student's average heart rate (AHR, beats per minute [bpm]) recorded in class. The second measure represented the percentage of time that students spent in and above their respective target heart rate zone (PTHR). The target heart rate zone was set according to the average age for each grade level. For example, the average age used for sixth grade was 11.5. The American College of Sports Medicine (ACSM) guidelines (2000) of 60% to 90% of maximum heart rate ($220 - \text{age}$) was used to determine target heart rate zone. For example, the target heart rate zone for sixth graders was 125 bpm to 188 bpm. These two outcome variables could be retrieved directly from the data outputs.

Procedures

The students' heart rates were measured during one physical education class, with all students wearing a heart rate monitor during the class session. A schedule was coordinated with the physical education teachers for the data collection from October to December 2006. The teachers were told that any data collection days should represent typical instructional days and should be viewed for normal physical education classes.

In this study, the heart rate monitors were distributed to students when the teachers were taking roll, and each student was assigned an identification number which matched the number on his or her heart rate monitor equipment (i.e., transmitter and receiver). The researchers assisted the students with attaching the heart rate monitors, and then checked to make sure they were correctly attached. At the start of the warm-up, the researchers let the students spread out and made sure each student kept an appropriate distance (i.e., three feet) from others to avoid multiple heart rate monitor interference. The students were then told to start the receivers of the heart rate monitors. At the end of each class, the students were instructed to stop the receivers. Meanwhile, the researchers recorded the lesson activity and activity time. The heart rate data were downloaded to a PC by the primary investigator at the end of each school day.

Data Analyses

Means and standard deviations were calculated for each of the output measures analyzed. Descriptive statistics were also computed for the measures across the curricular activities. In addition, a two-way (activity \times grade) MANOVA was performed to examine if mean scores of AHR and PTHR differed by activity and grade. Finally, follow-up univariate tests were conducted if MANOVA yielded main effects for activity and grade, and an interaction effect between activity and grade. A Bonferroni adjustment was

made to the alpha level to accommodate for pairwise comparisons. All statistical analyses were performed using SPSS 15.0.

Results

Table 1 shows the descriptive statistics for the four curricular activities, while Table 2 displays the descriptive statistics for three grades and the whole sample. The descriptive statistics indicate that students' AHR was 139.9bpm, with a range of 99 bpm to 183 bpm. The percentage of time students spent in and above their target heart rates varied from 0% to 100%, with an average of 55.43%. The students also showed considerable variability in their AHR ($SD = 16.23$) and time spent above their target heart rate ($SD = 23.95$).

Prior to the MANOVA analysis, the assumption of multivariate normality and the homogeneity of variance-covariance matrices were examined. The values of skewness ranged from -.40 to .16, suggesting that the variables were approximately normally distributed. The Box's M test, however, revealed that the assumption of homogeneity of variance-co-variance matrices was not met ($F = 1.65, p = .014$). To address the violation of this assumption (Tabachnick & Fidell, 2001), the alpha level for significance for the subsequent analyses was set at .01. Results of the MANOVA analysis indicated that there were no significant interaction effect between activity and grade. However, the main effects of activity (Wilks' Lambda = .77, $F [6, 266] = 6.24, p < .01$) and grade (Wilks' Lambda = .91, $F [4, 266] = 3.04, p < .01$) were significant. Cohen's η^2 was computed to assess the effect size of the significant differences. The values ranged from medium ($\eta^2 = .05$) to large ($\eta^2 = .12$), suggesting that the activity and grade effects are practically meaningful.

The follow-up test for AHR yielded a main effect for grade, $F (2, 134) = 4.31, p < .01$. In this study, sixth graders displayed higher AHR in physical education than eighth graders did. No other significant differences were found with this variable. The follow-up test for PTHR indicated that the main effects were significant for activity, $F (3, 134) = 8.48, p < .01$, and grade, $F (2, 134) = 5.83, p < .01$. Specifically, students in line dancing class exhibited significantly lower PTHR than those in other classes. In addition, sixth graders demonstrated higher PTHR than seventh and eighth graders did in physical education.

Discussion

This study focused on middle school students' heart rates and investigated the effects of four curricular activities (i.e., walking/jogging, line dancing, catch ball, and soccer) on their heart rate outcomes in physical education classes. It also examined the grade effect on students' heart rate outcomes. The following results were observed: (a) students in line dancing class exhibited significantly lower PTHR than those in catch ball, soccer, and walking/jogging classes; (b) younger students (i.e., sixth graders) displayed significantly higher AHR and PTHR than older students (i.e., eighth graders).

The results indicated that students spent an average of 55.43% time in and above their target heart rate zone (e.g., 60.92% for catch ball, 59.10% for soccer, and 52.71% for walking/jogging). This finding is promising and encouraging as the team sports and fitness activity classes met the Healthy People 2010 goal of a mini-

mum of 50% of the class time spent in physical activity (USDHHS, 2000). The team sports and fitness activity classes also echo the recommendations (i.e., 50% of the physical education class time should involve MVPA) by Sallis and Patrick (1994) and is in line with recent research (Arnett & Lutz, 2003; Kulinna et al., 2003). Although students in the line dancing class spent less than 40% time in and above their target heart rate zone, the line dancing class could be kept as one component of the curriculum because it can serve purposes other than increasing MVPA, such as motor skill development and cultural understanding.

In support of the first hypothesis that team sports and fitness activity promote relatively higher PA levels than individual activity, students in the soccer, catch ball, and walking/jogging classes demonstrated higher PTHR than those in the line dancing class. This was expected, as the team sports and walking/jogging involved a great deal of cardiovascular movement. The result is consistent with findings from previous studies (Hannon & Pellett, 1998; Laurson et al., 2008). Conversely, students' AHR did not differ significantly between the team sports, fitness activity, and individual activity, and therefore failed to support the first hypothesis. It is possible that AHR may not be a good indicator for an individual's PA levels, because different individuals have varying resting heart rates and vary in growth and maturation. Previous studies have provided similar findings in physical education classes. For example, in Kulinna et al.'s (2003) study, students' AHR was the highest for elementary games and hula-hoop, followed by fitness and several team sport activities. Future research might need to retrieve other physiological indicators that take resting heart rate into account (e.g., activity heart rate = AHR - resting heart rate) as the outcome variable. Taken together, our data partially support the first hypothesis.

Consistent with the second research hypothesis, students' AHR and PTHR declined from sixth grade to eighth grade. More specifically, sixth graders exhibited significantly higher AHR than eighth graders, and higher PTHR than seventh and eighth graders in this study. The result is consistent with the notion that students' PA levels in physical education decline across the middle school years (Klausen et al., 1986; Parish & Treasure, 2003; Stratton, 1997). Future research might include fifth grade and ninth grade to examine whether there are significant differences in heart rate based PA levels during the transition years from elementary to middle school or from middle to high school.

In summary, the most significant finding of this study is that the results revealed curricular activities and grade had differing effects on students' heart rate outcomes. Specifically, team sports (i.e., soccer, catch ball) and fitness activity (i.e., walking/jogging) promoted higher levels of PA than line dancing, while younger students were more physically active than older students. A few limitations, however, should be noted when interpreting the results. First, the participants came from one school and were from middle to high socioeconomic status families. Future studies need to recruit a large number of diverse students from multiple school sites to increase the accuracy and generalizability of the findings. The second limitation was the use of heart rate as an indirect estimate of physical activity. Other factors that might influence heart rate such as temperature and emotional stress were not controlled in this study. Additionally, the students being placed in different cur-

ricular activities were different individuals. In general, individuals tend to have different physical attributes (e.g., height, weight, and percent of body fat) and psychosocial disposition (e.g., motivation) which would significantly affect their PA levels in physical education class. Therefore, a future study could measure differences of the same group of students' PA levels when they are placed in multiple curricular activities sequentially. Finally, the teachers' approach might have an impact on students' heart rate outcomes. For example, the catch ball and soccer classes were organized with an emphasis on game play. If teachers focus on skill development there would be more instruction time that could produce different student heart rate results.

Despite these limitations, the results in this study may have significant implications for educational practice. That is, physical educators and school health professionals must consider physiological and physical effects that different curricular activities may have on students when designing and implementing physical education programs and after school PA programs. Specifically, team sports and fitness activity have been demonstrated to promote higher MVPA than line dancing. Therefore, physical education teachers and after school PA coordinators should incorporate team sports and fitness activity into their curriculum or programs to get students to be highly physically active on a daily basis.

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Appendix

Table 1. Descriptive Statistics for Each Variable by Activity (N = 146)					
Variable		Catch ball (n=60)	Walking/jogging (n=30)	Line dancing (n=22)	Soccer (n=34)
AHR	M	145.45	134.67	130.41	140.76
	SD	14.50	17.08	13.61	16.32
PTHR	M	60.92 ^a	52.71 ^a	38.45 ^b	59.10 ^a
	SD	17.56	31.86	20.90	23.05
Notes. M = mean; SD = Standard deviation. AHR = average heart rate; PTHR = percentage of time spent above target heart rate. ^{a,b} : there is a significant difference between the activities, <i>p</i> < .05.					

Table 2. Descriptive Statistics for Each Variable by Grade					
Variable		sixth (n=51)	seventh (n=33)	eighth (n=62)	Total sample (N = 146)
AHR	M	146.73 ^a	139	134.7 ^b	139.88
	SD	14.28	15.99	16.08	16.23
PTHR	M	65.27 ^a	54.18 ^b	47.99 ^b	55.43
	SD	19.53	25.37	23.99	23.95
Notes. M = mean; SD = Standard deviation. AHR = average heart rate; PTHR = percentage of time spent above target heart rate. ^{a,b} : there is a significant difference between the groups, <i>p</i> < .05.					